

CLAIMS

1. Apparatus for connecting at least a first Fibre Channel device that is capable of operating at a first physical link rate to at least a second Fibre Channel device that is capable of operating at a second physical link rate that is higher than said first physical link rate, the apparatus comprising:
 - a first port to which at least a first Fibre Channel device operating at a first physical link rate can be connected;
 - a second port to which at least a second Fibre Channel device operating at a second physical link rate can be connected;
- 10 15 20 25 30 a first buffer for storing data received at the first port from a said first Fibre Channel device and forwarding said data to the second port for transmission to a said second Fibre Channel device when a said first Fibre device wishes to send said data to a said second Fibre Channel device;
 - a second buffer for storing data received at the second port from a said second Fibre Channel device and forwarding said data to the first port for transmission to a said first Fibre Channel device when a said second Fibre Channel device wishes to send said data to a said first Fibre Channel device;
 - a first bypass buffer for storing data received at the first port from a said first Fibre Channel device and causing said data to be returned to the first port when a said first Fibre Channel device wishes to send said data to another Fibre Channel device connected to the first port; and,

a second bypass buffer for storing data received at the second port from a said second Fibre Channel device and causing said data to be returned to the second port when a said second Fibre Channel device wishes to send said data 5 to another Fibre Channel device connected to the second port;

whereby a said second Fibre Channel device can operate at said second physical link rate which is higher than said first physical link rate of a said first Fibre Channel 10 device regardless of whether or not a said first Fibre Channel device is sending data words to a said second Fibre Channel device and regardless of whether or not a said second Fibre Channel device is sending data words to a said first Fibre Channel device.

15 2. Apparatus according to claim 1, comprising a storage region for storing an Arbitrated Loop Physical Address (AL_PA) look-up table in which the Arbitrated Loop Physical Addresses (AL_PAs) of all devices connected to said first 20 and second ports are saved.

3. Apparatus according to claim 2, wherein the first and second ports are arranged to recognise LISM, LIFA, LIPA, LIHA and LISA frames.

25 4. Apparatus according to claim 3, wherein the first and second ports are arranged to compare the AL_PA bit maps of LIFA, LIPA, LIHA and LISA frames received at the first and second ports in order to identify which AL_PAs have been 30 assigned to devices connected to the first and second ports and to pass a result of said comparison to the storage region so that the AL_PAs of all devices connected to said

first and second ports can be saved in the AL_PA look-up table.

5. Apparatus according to any of claims 1 to 4, wherein
5 the first and second ports are arranged to send at least some Fill words received at the first port to the second port and to send at least some Fill words received at the second port to the first port, regardless of whether or not a said second Fibre Channel device is sending data words to 10 a said first Fibre Channel device and regardless of whether or not a said first Fibre Channel device is sending data words to a said second Fibre Channel device.

6. Apparatus according to any of claims 1 to 5, wherein
15 the first and second ports are arranged to send at least some ARB words received at the first port to the second port and to send at least some ARB words received at the second port to the first port, regardless of whether or not a said second Fibre Channel device is sending data words to 20 a said first Fibre Channel device and regardless of whether or not a said first Fibre Channel device is sending data words to a said second Fibre Channel device.

7. Apparatus according to any of claims 1 to 6, wherein
25 the first and second ports and the first and second bypass buffers are arranged such that, when non-identical ARB words are received at the first and second ports, arbitration between said non-identical ARB words is carried out and the winning ARB word of the arbitration process is 30 returned to the port at which it was received.

8. Apparatus according to any of claims 1 to 7, wherein the first and second ports are arranged such that at least

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some Primitive Sequences received at the first port are sent to the second port and such that at least some Primitive Sequences received at the second port are sent to the first port, regardless of whether or not a said second Fibre Channel device is sending data words to a said first Fibre Channel device and regardless of whether or not a said first Fibre Channel device is sending data words to a said second Fibre Channel device.

10 9. Apparatus according to any of claims 1 to 8, wherein the first buffer is arranged such that, when a said first Fibre Channel device wishes to send data words to a said second Fibre Channel device, frame data and Start of Frame and End of Frame delimiter words received at the first port from a said first Fibre Channel device are only forwarded by the first buffer to the second port when a predetermined amount of frame data has been stored in the first buffer.

10. Apparatus according to any of claims 1 to 9, wherein the second buffer is arranged such that, when a said second Fibre Channel device wishes to send data words to a said first Fibre Channel device, frame data and Start of Frame and End of Frame delimiter words received at the second port from a said second Fibre Channel device are only forwarded by the second buffer to the first port when a predetermined amount of frame data has been stored in the second buffer.

11. Apparatus according to any of claims 1 to 10, wherein the first and second bypass buffers are arranged such that, when a said first Fibre Channel device wishes to send data words to another Fibre Channel device connected to the first port, frame data and Start of Frame and End of Frame

delimiter words received at the first port from a said first Fibre Channel device are returned to the first port, and such that when a said second Fibre Channel device wishes to send data words to another Fibre Channel device 5 connected to the second port, frame data and Start of Frame and End of Frame delimiter words received at the second port from a said second Fibre Channel device are returned to the second port.

10 12. Apparatus according to any of claims 1 to 11, wherein the second port is arranged such that, when a said second Fibre Channel device wishes to send data words to a said first Fibre Channel device, the exact number of Non-Fill words received at the second port are forwarded to the 15 first port.

13. Apparatus according to claim 12, wherein the arrangement is such that if the second buffer is approaching a full state, R_RDY words received at the first 20 port are not transmitted to the second port until the second buffer has emptied sufficiently to receive more frames from a said second Fibre Channel device.

14. Apparatus according to any of claims 1 to 13, wherein the first port is arranged such that, when a said first Fibre Channel device wishes to send data words to a said second Fibre Channel device, the exact number of Non-Fill words received at the first port are forwarded to the 25 second port.

30 15. Apparatus according to any of claims 1 to 14, wherein the first and second bypass buffers are arranged such that, when a said first Fibre Channel device wishes to send data

words to another Fibre Channel device connected to the first port, Non-Fill words received at the first port from a said first Fibre Channel device are returned to the first port, and such that, when a said second Fibre Channel 5 device wishes to send data words to another Fibre Channel device connected to the second port, Non-Fill words received at the second port from a said second Fibre Channel device are returned to the second port.

10 16. A method of operating apparatus that connects at least a first Fibre Channel device that is capable of operating at a first physical link rate to at least a second Fibre Channel device that is capable of operating at a second physical link rate that is higher than said first physical 15 link rate, the apparatus having a first port to which the first Fibre Channel device capable of operating at the first physical link rate is connected, a second port to which the second Fibre Channel device capable of operating at the second physical link rate is connected, a first buffer, a second buffer, a first bypass buffer and a second bypass buffer, the method comprising:

when the first Fibre Channel device wishes to send data to the second Fibre Channel devices, storing said data received at the first port from the first Fibre Channel 25 device in the first buffer, forwarding said data to the second port and transmitting said data from the second port to the second Fibre Channel device;

when the second Fibre Channel device wishes to send data to the first Fibre Channel device, storing said data 30 received at the second port from the second Fibre Channel device in the second buffer, forwarding said data to the first port and transmitting said data from the first port to the first Fibre Channel device;

when the first Fibre Channel device wishes to send data to another Fibre Channel device connected to the first port, storing said data received at the first port from the first Fibre Channel device in the first bypass buffer and 5 causing said data to be returned to the first port; and,

when the second Fibre Channel device wishes to send data to another first Fibre Channel device connected to the second port, storing said data received at the second port from the second Fibre Channel device in the second bypass 10 buffer and causing said data to be returned to the second port;

whereby the second Fibre Channel device operates at the second physical link rate which is higher than the first physical link rate of the first Fibre Channel device 15 regardless of whether or not the first Fibre Channel device is sending data words to the second Fibre Channel device and regardless of whether or not the second Fibre Channel device is sending data words to the first Fibre Channel device.

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17. A method according to claim 16, comprising saving the Arbitrated Loop Physical Addresses (AL_PAs) of all devices connected to said first and second ports in an Arbitrated Loop Physical Address (AL_PA) look-up table.

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18. A method according to claim 17, wherein the first and second ports recognise LISM, LIFA, LIPA, LIHA and LISA frames.

30 19. A method according to claim 18, wherein the first and second ports compare the AL_PA bit maps of LIFA, LIPA, LIHA and LISA frames received at the first and second ports in order to identify which AL_PAs have been assigned to

devices connected to the first and second ports and pass a result of said comparison to the look-up table so that the AL_PAs of all devices connected to said first and second ports are saved in the AL_PA look-up table.

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20. A method according to any of claims 16 to 19, wherein the first and second ports send at least some Fill words received at the first port to the second port and send at least some Fill words received at the second port to the 10 first port, regardless of whether or not the second Fibre Channel device is sending data words to the first Fibre Channel device and regardless of whether or not the first Fibre Channel device is sending data words to the second Fibre Channel device.

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21. A method according to any of claims 16 to 20, wherein the first and second ports send at least some ARB words received at the first port to the second port and send at least some ARB words received at the second port to the 20 first port, regardless of whether or not the second Fibre Channel device is sending data words to the first Fibre Channel device and regardless of whether or not the first Fibre Channel device is sending data words to the second Fibre Channel device.

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22. A method according to any of claims 16 to 21, wherein when non-identical ARB words are received at the first and second ports, arbitration between said non-identical ARB words is carried out and the winning ARB word of the 30 arbitration process is returned to the port at which it was received.

23. A method according to any of claims 16 to 22, wherein at least some Primitive Sequences received at the first port are sent to the second port and at least some Primitive Sequences received at the second port are sent to the first port, regardless of whether or not the second Fibre Channel device is sending data words to the first Fibre Channel device and regardless of whether or not the first Fibre Channel device is sending data words to the second Fibre Channel device.

10 24. A method according to any of claims 16 to 23, wherein when the first Fibre Channel device wishes to send data words to the second Fibre Channel device, frame data and Start of Frame and End of Frame delimiter words received at the first port from the first Fibre Channel device are only forwarded by the first buffer to the second port when a predetermined amount of frame data has been stored in the first buffer.

20 25. A method according to any of claims 16 to 24, wherein when the second Fibre Channel device wishes to send data words to the first Fibre Channel device, frame data and Start of Frame and End of Frame delimiter words received at the second port from the second Fibre Channel device are only forwarded by the second buffer to the first port when a predetermined amount of frame data has been stored in the second buffer.

26. A method according to any of claims 16 to 25, wherein 30 when the first Fibre Channel device wishes to send data words to another Fibre Channel device connected to the first port, frame data and Start of Frame and End of Frame delimiter words received at the first port from the first

Fibre Channel device are returned to the first port, and when the second Fibre Channel device wishes to send data words to another Fibre Channel device connected to the second port, frame data and Start of Frame and End of Frame 5 delimiter words received at the second port from the second Fibre Channel device are returned to the second port.

27. A method according to any of claims 16 to 26, wherein when the second Fibre Channel devices wishes to send data 10 words to the first Fibre Channel device, the exact number of Non-Fill words received at the second port are forwarded to the first port.

28. A method according to claim 27, wherein if the second 15 buffer is approaching a full state, R_RDY words received at the first port are not transmitted to the second port until the second buffer has emptied sufficiently to receive more frames from the second Fibre Channel device.

20 29. A method according to any of claims 16 to 25, wherein when the first Fibre Channel devices wishes to send data words to the second Fibre Channel device, the exact number 15 of Non-Fill words received at the first port are forwarded to the second port.

25 30. A method according to any of claims 16 to 26, wherein when the first Fibre Channel devices wishes to send data words to another Fibre Channel device connected to the first port, Non-Fill words received at the first port from 30 the first Fibre Channel device are returned to the first port, and, when the second Fibre Channel device wishes to send data words to another Fibre Channel device connected to the second port, Non-Fill words received at the second

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port from the second Fibre Channel device are returned to
the second port.